DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Submission of Proposals

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified 49 technical topics, numbered **DARPA SB971-001** through **DARPA SB971-049**, to which small businesses may respond in the first fiscal year (FY) 97 solicitation (97.1). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included, followed by full topic descriptions. The topics originated from DARPA technical offices.

DARPA Phase I awards are limited to **$99,000**. DARPA Phase II proposals must be invited by the respective Phase I technical monitor. Phase II proposals are encouraged at the amount of $375,000 with additional funding available for optional tasks. The entire Phase II effort should not exceed $750,000.

The responsibility for implementing DARPA's SBIR Program rests with the Office of Administration and Small Business (OASB). The DARPA SBIR Program Manager is Ms. Connie Jacobs. DARPA invites small businesses to send proposals directly to DARPA at the following address:

DARPA/OASB/SBIR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714
(703) 522-1754

Additional information regarding DARPA and the DARPA SBIR Program may be found on the World Wide Web DARPA Home Page at http://www.darpa.mil. During the Pre-Solicitation period (approximately 6 weeks before the solicitation opens) DARPA Program Managers may be contacted to discuss technical issues related to their topics. For a list of the Topic Points of Contact, please see the Pre-Solicitation release. E-mail is the most effective means of communicating with DARPA Program Managers. The e-mail address for all DARPA employees is (First initial of First Name) (Last Name) @darpa.mil. If you have trouble reaching a designated POC, please contact Connie Jacobs directly at cjacobs@darpa.mil.

SBIR proposals submitted to DARPA will be processed by DARPA OASB and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based upon technical merit and the evaluation criteria contained in this solicitation document. As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) in question is deemed superior, or it may fund no proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

In order to ensure an expeditious award, cost proposals will be considered to be binding for a period of 180 days from the date of closing of this solicitation. Please note that **one original and 4 copies** of each proposal must be mailed or hand-carried; DARPA will **not** accept proposal submissions by electronic facsimile (fax). A checklist has been prepared to assist small business activities in responding to DARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to DARPA. Do not include the checklist with your proposal.

DARPA 1997 Phase I SBIR
Checklist

1) Proposal Format

   a. Cover Sheet - Appendix A (identify topic number) ______

   b. Project Summary - Appendix B ______

   c. Identification and Significance of Problem or Opportunity ______

   d. Phase I Technical Objectives ______

   e. Phase I Work Plan ______

   f. Related Work ______

   g. Relationship with Future Research and/or Development ______

   h. Potential Post Applications ______

   i. Key Personnel ______

   j. Facilities/Equipment ______

   k. Consultant ______

   l. Prior, Current, or Pending Support ______

   m. Cost Proposal (see Appendix C of this Solicitation) ______

   n. Prior SBIR Awards ______

2) Bindings

   a. Staple proposals in upper left-hand corner. ______

   b. **Do not** use a cover. ______

   c. **Do not** use special bindings. ______

3) Page Limitation

   a. Total for each proposal is 25 pages inclusive of cost proposal and resumes. ______

   b. Beyond the 25 page limit do not send appendices, attachments and/or additional references. ______

4) Submission Requirement for Each Proposal

a. Original proposal, including signed **RED** Appendices A and B. ______

b. Four photocopies of original proposal, including signed Appendices A and B. ______

c. One additional photocopy of Appendices A and B only. ______

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DARPA SB971-003	Materials and Processes for High Performance Electromechanical Actuation
DARPA SB971-004	Molecular Therapeutics for Modulation of Pathogenesis
DARPA SB971-005	Clean Fuel Sources for Proton Exchange Membrane (PEM) and Solid Oxide Fuel Cells (SOFC)
DARPA SB971-006	System and Security Management Tools
DARPA SB971-007	Tools for Software System Understanding and Transformation
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DARPA SB971-014	Efficient External Modulators for Radio Frequency (RF) Photonic Systems
DARPA SB971-015	Wideband Photonic Radio Frequency (RF) Signal Processors
DARPA SB971-016	Stand Off Chemical and Biological (Chem/Bio) Hazard Detection
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DARPA SB971-020	Advanced Propulsion and Power Technologies for Micro Air Vehicle (µAV) Systems
DARPA SB971-021	Diver-Held Sonar
DARPA SB971-022	Antenna Element Location Measurement System for Millimeter Wave, Airborne Antennas
DARPA SB971-023	Robust Guidance, Navigation, and Control (GN&C)
DARPA SB971-024	Unique Concepts for Rotorless High-Speed Vertical Takeoff and Landing (VTOL) Aircraft

DARPA SB971-025	Innovative Concepts For Space-Based Remote Sensing
DARPA SB971-026	Precise Attitude Measurement
DARPA SB971-027	Advanced Synthetic Aperture Radar (SAR) Waveforms
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DARPA SB971-044	High-Speed Fiber Optic Network Access Modules (NAMs)
DARPA SB971-045	Innovative Research in the Area of Digital Receivers for Radar, Electronic Warfare, and Communications Applications
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DARPA SB971-047	Nanoelectronic Structures and Devices
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DARPA 97.1 TOPIC DESCRIPTIONS

DARPA SB971-001 TITLE: Rapid Design and Prototyping of Advanced Alloys or Composites via Solid Freeform Fabrication (SFF)

CATEGORY: 6.2 Exploratory Development; Manufacturing Science and Technology

OBJECTIVE: Demonstrate the machine capability to build advanced alloy or composite components from computer aided design (CAD) files without part-specific tooling or operator intervention.

DESCRIPTION: SFF capabilities are of great interest to DoD for reducing the time and cost of prototyping components and low-volume production. SFF approaches, such as Fused Deposition Modeling (FDM), Laminate Object Manufacturing (LOM), Stereo Lithography (SLA), Scanning Laser Sintering (SLS), and 3-D Printing, have been developed to make components for "form and fit," and are increasingly being used to manufacture soft tooling for low-volume manufacture and, more recently, components with "form, fit, and function." This topic seeks to expand the component capability of advanced materials which can be made by SFF techniques. Advanced alloys of interest include, but are not limited to, titanium and beryllium. SFF capability for fabrication of metal matrix composites, or functionally graded materials or porous metals or devices will also be entertained under this topic.

PHASE I: Demonstrate the feasibility of the chosen SFF technique to produce components with the same properties as comparable, commercially produced components.

PHASE II: Demonstrate the rapid design, prototyping, test, and evaluation of components with both defense and commercial relevance based on the capabilities developed in Phase I.

COMMERCIAL POTENTIAL: SFF manufacturing capabilities are ideally suited to prototyping and small-volume production of advanced materials which lack a high volume manufacturing base. These niche markets are particularly attractive to small, agile firms.

DARPA SB971-002 TITLE: Tissue Regeneration

CATEGORY: 6.1 Basic Research; Biomedical

OBJECTIVE: Discover new biomimetic materials and cellular constructs with the potential to replace tissue loss from combat wounds by tissue regeneration.

DESCRIPTION: Casualties and permanent disabilities occur from loss of vital structures (tissues, organs, etc.) as a result of traumatic combat wounds. Today there exists the potential to exploit emerging biomimetic materials alone or in conjunction with cellular biotechnologies (e.g., stem cells) in order to provide temporary homeostasis and wound coverage immediately after wounding, and to initiate the wound healing and tissue regeneration process while still on the battlefield. In the future, rear echelon medical care would include materials/cells which provide replacement of lost tissues (e.g., muscles, bones, cartilages) or even organ systems (e.g., liver, kidney, etc.). This will require integration of the latest breakthrough technologies in biomaterials for scaffolding (e.g., self-replication, self-assembly, etc.), and in biotechnology for tissue replacement and regeneration (e.g., stem cells, genetic engineering, etc.).

PHASE I: Identify biomimetic materials and cell lines suitable to replace tissue loss from combat wounds by tissue regeneration. Develop biomaterials as substrate/scaffold for tissue growth.

PHASE II: Develop an organ level tissue requiring integration of multiple cell lines, biomaterials, and intricate three dimensional framework.

COMMERCIAL POTENTIAL: In trauma and ablative surgery (e.g., cancer, massive infections, etc.), a tissue or organ replacement will provide a return to near normal functioning when massive amounts of tissues or organs are lost. Organ transplantation is the fastest growing area in medicine today; however, this requires donors. Tissue or organ replacement can provide a substitute for transplantation and help meet the enormous demand for tissue and organs today.

DARPA SB971-003 TITLE: Materials and Processes for High Performance Electromechanical Actuation

CATEGORY: 6.2 Exploratory Development; Materials, Processes and Structures

OBJECTIVE: An innovative material or material processing regimen that results in improved performance of electromechanical actuators.

DESCRIPTION: Development efforts will address synthesis and processing of the materials (piezoelectrics, electrostrictors, magnetostrictors, shape memory alloys, etc.) that lie at the heart of electromechanical actuators, performing the essential task of converting electrical energy to mechanical. The materials technology developed will improve one or more actuator performance characteristic, for example, larger displacements, higher force levels, greater energy efficiency, or faster response times. While the development focuses on the material and its processing, proposed efforts should target candidate actuator devices or systems that will capitalize on the material's property enhancement.

PHASE I: Establish feasibility of proposed materials synthesis route or processing regimen, and identify candidate device/systems application where this innovation will result in higher performance electromechanical actuation.

PHASE II: Develop materials synthesis or processing, fabricate enhanced electromechanical actuator, and demonstrate improved performance in targeted devices/systems.

COMMERCIAL POTENTIAL: High performance electromechanical actuators are key components in realizing a great variety of advanced defense systems (e.g., helicopter rotor control, airfoil shape control, and shipboard vibration control) and commercial systems (e.g., machine tool control, aircraft cabin noise control, and automobile suspensions). Emerging applications such as these provide substantial markets for an advanced material technology that opens an affordable route to meeting their demanding actuation requirements.

DARPA SB971-004 TITLE: Molecular Therapeutics for Modulation of Pathogenesis

CATEGORY: 6.1 Basic Research; Biomedical

OBJECTIVE: Demonstrate the feasibility of infectious disease therapeutics based on targeting shared virulence mechanisms.

DESCRIPTION: This topic seeks to demonstrate the feasibility of new intervention or treatment modalities for exposure to highly virulent pathogens or toxins. Because the pathogen often may not be immediately identified, approaches to affect underlying pathogenetic mechanisms that may be common to many severe infections, or approaches that might be effective on a broad class of pathogens are of special interest. Examples might include manipulation of cytokines to alter pathogenesis, modulation of the expression or activity of virulence factors in-vivo, or passive immunotherapeutics. Improved vehicles, devices, or mechanisms for delivery of molecular therapeutic agents are also of interest.

PHASE I: Identify a suitable candidate target (or targets) and determine the feasibility of the chosen approach.

PHASE II: Demonstrate feasibility in-vivo and determine suitable means of therapeutic administration.

COMMERCIAL POTENTIAL: There are currently few interventions for many severe infections and therefore no existing competition in this market. The underlying principles are also likely to be applicable to other types of diseases with large potential markets such as autoimmune disease and a wide variety of less severe infections.

DARPA SB971-005 TITLE: Clean Fuel Sources for Proton Exchange Membrane (PEM) and Solid Oxide Fuel Cells (SOFC)

CATEGORY: 6.2 Exploratory Development; Materials, Processes and Structures

OBJECTIVE: Starting from logistics fuels, e.g., JP-8, DF-2, develop fuel processing technology for PEM and SOFC in the 50 W to 1 kW range.

DESCRIPTION: DoD has considerable interest in compact power sources that can exceed the endurance of batteries by a significant margin. To this end, several DARPA sponsored programs have focused on the development of fuel cells spanning the size range from tens of watts to tens of kilowatts. Applications include, but are not restricted to, individual soldier power, battery chargers, diesel generator replacements, auxiliary power units, and mobile electric power. Operation on logistics fuels is a requirement for the larger systems, as acceptance of a new fuel by the logistics chain is highly unlikely. Alternative fuels, e.g., methanol, may be acceptable on the short term for smaller systems because, from a logistics standpoint, it can be packaged and handled like a primary battery pack. Ultimately, fuel cells operating on logistics fuels will be needed to meet future requirements. This topic seeks proposals that will significantly improve logistics fuel processing technology for small fuel cells (PEM and SOFC) in the power range of 50 W to 1 kW. The following issues should be addressed in the proposal: 1) system size and weight; 2) operational complexity and maintenance; 3) compatibility with existing PEM or SOFC technology, with respect to load following, fuel purity, startup and shutdown; 4) safety; and 5) efficiency.

PHASE I: Demonstrate a proof-of-concept logistics fuel processor for small PEM or SOFCs in the 50 W to 1 kW power range.

PHASE II: Demonstrate an integrated logistics fuel processor with a PEM or SOFC in the 50 W to 1 kW power range.

COMMERCIAL POTENTIAL: The development of compact fuel cell technology that operates on logistics fuels will enable the development of highly efficient, quiet, environmentally compliant power sources for consumer applications, e.g., lawn mowers, emergency power units, and recreational activities (camping, boating, etc.).

DARPA SB971-006 TITLE: System and Security Management Tools

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Enhance and/or expand the set of administrative, diagnostic, and system management tools available to network managers and system administrators to securely manage large, complex, heterogeneous networked and distributed systems in the presence of ordinary failure and possible malicious activity.

DESCRIPTION: The intent of this topic is to solicit research and development leading to system management tools with broad applicability to today's widely fielded, heterogeneous systems. Of particular interest are tools that combine functions of security monitoring and intrusion detection with those of system failure diagnosis and repair. The diagnostic functions should enable the determination of the source and scope of the problem, discrimination among kinds of problems, diagnosis in the face of limited information, distributed diagnosis, and scalable diagnosis in very large heterogeneous networks. Among functions that could be considered for such tools are configuration checking (to ensure a system configuration is secure), intrusion detection (continuous monitoring and detection of suspicious activity), self-test and diagnostics (identifying root causes of perceived problems), penetration analysis (for rapid damage assessment and system recovery), and control functions (for reconfiguration, maintenance and correction/repair). Tools for instrumentation of systems and networks for the collection of appropriate data for analysis are also needed.

Of special interest are tools that allow a system to be reconfigured to adapt to changes due to failures, attack, or normal system evolution. Tools to be developed might allow a system to have an anticipatory reaction (based on predicting where the problem will strike next, or the next stage of an attack), problem isolation and containment, and warm or cold restart. Also of interest are standardized Application Program Interfaces (APIs) for testing and sharing management information across administrative domains. Novel approaches are desired for tools that will: 1) improve the capture of relevant information in real-time, with reductions in both system processing overhead and human intervention; 2) reduce the labor-intensive operations associated with system management, security management, and incident response; and 3) improve testing of the effectiveness and efficiency of system safeguards. Proposals must clearly state the analytical methods to be employed and must include a task that evaluates the success of the methods for the application. Earlier techniques and tools that were taken as far as the proof-of-concept stage may be reused and extended. Proposals to enhance existing tools, to make them more broadly applicable, will also be considered. The capabilities of these new or enhanced tools should go well beyond what has previously been done. Solutions must be scalable for use in extremely large heterogeneous computing and communications networks. Special attention must be paid to ease of use. Proposals must clearly state the scale of the system targeted.

PHASE I: In detail, define the application, the analytical techniques or algorithms to be used, the approach to and limits of scalability, and quantify the expected benefits. Produce a detailed design of the tool to be implemented. Relevant tools are those which will bring greater efficiency and security to system operations and management. From experiences with current tools, it is becoming clear that such tools need to be easier to manage, provide more automated diagnosis and intervention/repair, and provide better instrumentation for data collection and control/response.

PHASE II: Produce a prototype of the tool, its documentation, and an experimental evaluation of its effectiveness. Complete documentation of test cases and results must be delivered. The documented experimental evidence should make it clear whether there is a marked increase in continuous operations and security as a result of the tool, as well as demonstrate the improvement in the tool's ease of use. Such demonstrations may require the use of test subjects to develop necessary supporting statistics. The tool developer should provide estimates regarding the acquisition costs and operational performance costs of using the tool, including hardware and software costs, processing overhead, storage and bandwidth requirements, and management costs.

COMMERCIAL POTENTIAL: The development of scalable, easy-to-use system security and management tools that can be used to analyze and manage very large, heterogeneous computing and communications systems will help feed the growing market for tools to safeguard systems from attack by internal or external penetrators, and to help system managers perform their jobs without need for extensive security expertise. These tools can help to establish new markets for management tools and services. For example, tools to check security configuration can be used by a commercial security certification service; tools for damage assessment and incident recovery can be used by a commercial incident response service. Making such tools more cost effective and easier to use should enhance making any potential commercial security analysis service a profitable endeavor.

DARPA SB971-007 TITLE: <u>Tools for Software System Understanding and Transformation</u>

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Demonstrate software technology that supports the evolution and modification of legacy software systems by "reverse engineering" of the system into an evolvable, architecturally-oriented description.

DESCRIPTION: This topic seeks to develop semi-automated tools to design recovery of legacy software systems and their restructuring into evolvable systems. For a system to be evolvable it must be annotated with a structured, machine processible description which: 1) represents the system at an architectural level with appropriately modularized components, 2) relates these to standard programming clichés and architectural patterns, and 3) captures the rationale for the structure of the system. Tools and techniques relevant to this overall goal include: 1) domain specific software architectures and reuse repositories which reduce development cost and time by allowing the use of "plug compatible" software components; 2) design representations and tools that reduce the cost and risk of reusing existing components by maintaining a "design record" to explain a component's structure, behavior, and constraints on its use; and 3) reverse engineering tools to support design recovery and restructuring of existing software assets. These include slicing and related analysis techniques, software pattern matching tools, cliché recognition techniques, etc.

PHASE I: In detail, define the domain of applicability of the tool and the set of techniques to be employed, and analyze their limitations. Conduct exploratory implementations. Produce a detailed design of the final tool.

PHASE II: Produce a prototype implementation of the tool set, its documentation, and experimental demonstrations of its effectiveness.

COMMERCIAL POTENTIAL: A specific opportunity for such tools is management of the Year 2000 problem. Large volumes of commercial and DoD software have been written using limited sized fields to represent dates. Many of these programs will fail as the turn of the century approaches. Often the dates are not explicitly tagged as such. In addition, it is difficult to determine where computations on dates are performed in the system. Tools of this type can help identify and fix these problems. More generally, there exist billions of dollars worth of legacy code, written in obsolete programming languages, for which the design rationale has long been lost. Tools which can help recover structure and rationale will find a very large market.

DARPA SB971-008 TITLE: Tools for Safe, Efficient Mobile Code in Heterogeneous Networked Environments

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Demonstrate robust prototypes of tools to compile, optimize, verify, and/or instrument mobile code for safe, efficient execution on networked heterogeneous hosts.

DESCRIPTION: The emergence of large-scale, heterogeneous networked computing environments and the World Wide Web has created a demand for programs that execute safely and efficiently on arbitrary host architectures, regardless of the source of the code. The Java solution is biased toward safety, requiring such programs to be written in a particular language, and ensuring safety through the type system of that language, local verification of the byte-code intermediate form, and interpretation rather than execution. These safeguards, while imperfect, ensure some degree of protection of the local system at the expense of efficiency and scalability to large programs. While commercial byte-code compilers promise to address efficiency concerns, they may do so by sacrificing safety and ignoring the complex tradeoffs among safety, compilation time, execution time, and interpretation time that can only be made dynamically.

Advanced tools are required to: verify the safety of mobile code; instrument that code to detect memory errors, unauthorized resource accesses, or system calls; efficiently compile and optimize code for best performance on the user's host machine; make dynamic decisions on whether compilation or interpretation is the best strategy (including possible hybrid interpretation/incremental compilation approaches); and dynamically recompile segments of the code using run-time dependence information. Languages of interest are not limited to Java, but may include other familiar languages such as C, C++, and ML, or annotated dialects thereof.

PHASE I: Identify target source and intermediate language(s), requirements, and high-level design of tool suite. Demonstrate proof-of-concepts on at least two different host platforms (architecture/OS). Demonstrate validity of safety and verification claims.

PHASE II: Complete reference implementation of tool set. Port to, and demonstrate on, at least three different host platforms. Demonstrate scalability and dynamic features.

COMMERCIAL POTENTIAL: The explosion of the World Wide Web has generated substantial commercial interest in mobile code as a means of providing flexible, extensible, enhanced web services for information dissemination and electronic commerce. The technology described here will greatly expand the scope of feasible services by addressing the critical issues of safety and efficiency, enabling deployment of more complex applications, and instilling greater confidence in the end user.

DARPA SB971-009 TITLE: Adaptive Network Security Management

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Design and develop software for configuring security mechanisms in response to stress situations in the management of computer networks.

DESCRIPTION: The Internet environment poses many threats to connected systems. Firewalls and other strong access controls help mitigate the risks, but there are no perfect mechanisms. When the security of a system (LAN, enclave, virtual network, etc.) is breached, a response must be initiated. In the current state-of-the-art, these responses are initiated by system managers on an ad-hoc basis, in response to some anomaly or advisory. Significant effort is being invested in the detection of security anomalies via intrusion detection and various emergency bulletins from centralized organizations. There has been less work in developing detailed response scenarios for affected organizations, yet there are a number of mechanisms available to system administrators that can adjust the "openness" of the security mechanisms in order to protect organizational resources. Examples include increasing audit logging, selectively disabling remote services, and disabling selected accounts.

An environment that allows a system administrator to easily manage the mapping between security alerts, and response scenarios that reconfigure the network system security mechanisms into an appropriately defensive stance, would increase the survivability of systems to new or newly discovered vulnerabilities in network software. Allowing administrators to tailor the responses to their particular environments would give them the flexibility to introduce new protective mechanisms and deploy them appropriately. This adaptation increases the utility of the system overall by allowing it to remain as accessible as is appropriate under the changing environmental conditions.

PHASE I: Develop three components of the adaptive management system in a detailed design: 1) a characterization of the interfaces for receiving prerequisite and classifying security alarm information from human or automated intrusion detection; 2) a characterization of the response mechanisms, their purposes, and their interdependencies with critical systems services; and 3) scenarios developed as scripts (for example) that form a coordinated response, ranging from such possible examples as simple one-step e-mail messages, to establishing removing all remote access to a LAN. An easily manipulated user interface for creating and installing alert/response mappings should also be detailed.

PHASE II: Develop the detailed design as a fully operational software system on a commercially-available platform, including Internet services and firewall technology.

COMMERCIAL POTENTIAL: This adaptive response mechanism can be incorporated into LAN configuration tools and system security administration tools. It can be used to protect legacy systems and to interact with new software that is more security savvy than older systems.

REFERENCES:
1. World Wide Web DARPA/ITO home page, http://www.ito.darpa.mil
2. High Performance Computing and Communications "Blue Book" for 1996 and 1997, http://www.hpcc.gov

DARPA SB971-010 TITLE: Scalable and Robust Implementations of Tools and Environments for High Performance Systems

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Creation or robust implementation of software tools and environments which can reduce the time to enable and improve the quality of implementation of high performance computing and data intensive applications.

DESCRIPTION: The intent of this topic is to solicit research and development leading to prototype tools supporting the development needs of high performance applications, such as the ones developed under the federal High Performance Computing and Communications (HPCC) Program. Efforts may encompass the development of novel software tools or the creation of robust implementations of existing prototypes of software tools and environments geared to address the needs of high performance applications characterized by numerically-intensive computational requirements, as well as communication and I/O requirements. Such tools and environments include, but are not limited to, language preprocessors, compilers, code schedulers, code transformers, software library managers, debuggers, application development visualization tools, and performance analysis visualization tools. Easy to use, robust and scalable implementations are highly desirable, as well as implementations that deal with porting said applications on heterogeneous distributed computing environments. Special emphasis will be placed on tools and environments that support large scale parallel systems and those that can support (heterogeneous) distributed systems.

PHASE I: In detail, define the tool or environment to be developed, the software architecture, the technical approaches, interfaces, tradeoffs, and enhancements over current approaches or existing tools, together with feasibility analysis, identifying the testbed applications, and providing measurable criteria of the validity and success of the approach.

PHASE II: Prototype, develop, demonstrate, evaluate, and deliver software development tools and integrated support environments for porting and executing high performance applications, along with evidence that demonstrates the enhancements made by this work. Provide the associated documentation for using the tool or environment.

COMMERCIAL POTENTIAL: Lack of adequate, and in particular robust and scalable, software tools has hampered the wider use and exploitation of today's high performance parallel and distributed systems. The present effort can contribute toward creating tools that remain robust at the range of large numbers of processors, which will aid and expedite the porting of DoD critical applications on today's parallel and distributed high performance machines.

DARPA SB971-011 TITLE: ~~Rapidly Deployable Nomadic Routers~~

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Creation of routers that can be rapidly and easily deployed in areas with little or no fixed infrastructure.

DESCRIPTION: The intent of this topic is to solicit research and development leading to the creation of small routers capable of connecting into a wireless internetwork. Efforts may address any combination of single or multihop wireless radio technology, satellite networks, or cellular telephone systems. Efforts may either build upon existing routing and access algorithms for multihop wireless communications and nomadic routing, or may propose to develop new algorithms. In all cases, proposals must clearly state the throughput goals; geographic coverage targets; and projected size, weight, and power requirements for the routers.

PHASE I: In detail, define the specification for a proposed wireless, nomadic router and produce a design.

PHASE II: Create a set of nomadic routers capable of deployment within a campus or metropolitan size region. Demonstrate that the routers meet the performance goals established in the Phase I proposal. Complete documentation of test cases and results must be delivered.

COMMERCIAL POTENTIAL: The development of rapidly deployable wireless routers will expand the commercial market for access to information sources and content across a fixed infrastructure. Timely access to such information will become possible from remote areas. Such access should benefit dual-use applications, such as deployment of resources to rapidly respond to unpredictable crises of either a military or emergency nature.

DARPA SB971-012 TITLE: ~~Low-Cost Technique for Measuring Distributed Strain and Temperature in Long Optical Fibers~~

CATEGORY: 6.2 Exploratory Research; Electronics

OBJECTIVE: Develop a low-cost fiber optic sensor that is capable of accurately measuring the strain distribution in optical fibers that are (1) wound for high-speed payout applications [e.g. U.S. Army Missile Command projects such as Extended Range Fiber Optic Guided Missile (EFOGM) and Long Range Fiber Optic Guided Missile (LONGFOG)], and (2) embedded in various composite structures. Develop a strain sensor that can resolve strains in dynamic environments such as precision-wound bobbins undergoing temperature variations in buildings and lifeline facilities (e.g. bridges) in the presence of passing seismic waves.

DESCRIPTION: Optical fibers have been precision-wound for high-speed deployment in a variety of fiber optic tethered vehicles and weapon systems for more than a decade. The wound fiber pack must maintain mechanical stability during long-term storage and operation (high-speed payout) over military environments. The issue of residual tensions throughout the wound pack becomes more critical as the required number of layers increases, and the system demands for increased speed and range grow. The number of layers required for next generation fiber optic guidance systems have more than tripled. A low-cost, non-destructive measurement technique that can provide a strain/temperature profile along the entire length of fiber during the winding process and in a storage environment (temperature cycling and ramps) is needed. The measurement technique must be capable of resolving the strain and strain changes between the individual layers. Strain sensitivities less than 10^{-5} with a time resolution of 10 Hz are required. The sensor should be capable of resolving less than 1º C temperature changes along the fiber length. The outcome of this project should provide the fiber optic bobbin designer with a non-destructive measurement technique to aid in optimizing the winding tension profile required to uniformly distribute the energy throughout the pack upon the completion of the winding process.

PHASE I: Investigate various fiber optic strain sensing techniques for measuring distributed strain and temperature in long (up to 50 km) optical fibers. Provide detailed analysis of all feasible solutions. Recommend a low-cost approach that will meet the criteria described above.

PHASE II: Develop and demonstrate the selected fiber strain/temperature sensing technique from Phase I. Perform testing to verify the performance of the fiber optic sensor system. Provide detailed description of the equipment and materials. Provide a laboratory demonstration of the system/equipment. Provide test data.

COMMERCIAL POTENTIAL: This SBIR project is intended to investigate optical techniques to accurately measure the strain and strain changes in each individual layer of wound fiber in a fiber optic dispenser. The sensor technique has direct application to measuring strains/temperatures in various composite smart structures (containing embedded optical fibers), at sites coincident with seismometers, in bridges, in buildings undergoing seismic waves, across active faults, down-hole through glaciers, etc.

DARPA SB971-013 TITLE: <u>Spatial Light Modulator (SLM) with Independent Phase and Amplitude Modulation</u>

CATEGORY: 6.1 Basic Research; Electronics

OBJECTIVE: Further the development of SLM technology by providing a device with independent control of phase and amplitude modulation. This capability is extremely critical in both optical processing and holographic imaging.

DESCRIPTION: The critical component in many optical processing architectures is the SLM. The SLM is usually employed both in the input plane and in the filter or programming plane of the system. Many electronically controlled SLMs have the capability to independently modulate either the amplitude or the phase of the incident coherent light. Some of these modulators also exhibit a coupled phase and amplitude response. No modulator currently exists, however, with independent control of both phase and amplitude. This has limited the performance of optical processing systems by forcing a “best fit” approach rather than actually realizing the fully complex design of most filters. It also limits the resolution and image quality of holographic display systems based on SLMs. Recent advances in the technology offer the possibility of achieving the ability to control phase and amplitude independently on a pixel by pixel basis.

PHASE I: Demonstrate a small array (at least 4 x 4) of electronically controlled pixels capable of modulating a coherent light source. Each pixel should provide the ability to independently control the phase and amplitude of the exit beam at rates exceeding 10 kHz. Phase I will be used to provide the design of the individual pixel, provide a system architecture for a full scale device with at least 512 x 512 pixels and a 1 kHz frame rate, and demonstrate a proof-of-concept small array.

PHASE II: Fabricate, demonstrate, and deliver a full scale device based on lessons learned in Phase I. This device should have at least 512 x 512 pixels and provide a 1 kHz frame rate.

COMMERCIAL POTENTIAL: Commercial interest in optical processing applications, such as machine vision and security, has been demonstrated by several companies. The successful completion of this SBIR will have a tremendous impact on the performance of the prototype systems currently under development, and should result in increased interest. Holographic imaging systems based on this device also have potential in the medical and topographical imaging arenas.

DARPA SB971-014 TITLE: <u>Efficient External Modulators for Radio Frequency (RF) Photonic Systems</u>

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Electronic Warfare

OBJECTIVE: Develop highly efficient electro-optic modulators to enable near-lossless conversion of analog electronic signals to the optical domain for RF photonic systems.

DESCRIPTION: The intent of this topic is to solicit research and development leading to electro-optic modulators capable of high efficiency conversion of RF carrier-based signals to optical carrier -based signals. Efficiency is defined by modulation depth: 10% optical modulation depth equals 10% efficiency; 100% modulation depth equals 100% efficiency. Linearity of conversion is of paramount importance. Conversion (modulation) must be performed without the use of electronic amplifiers. Operation at 1.3 or 1.55 microns is of interest. Polarization independent operation is also of interest. Modulators that convert analog RF signals to optical intensity (magnitude squared of field) or to optical amplitude are both of interest. Frequency of operation from 1 GHz to 100 GHz is desirable. Military systems influenced include antenna systems, RF receivers, satellite communications, electronic warfare (EW) systems, and electronic signals intelligence (ELINT) systems.

PHASE I: Tradeoff design approaches and develop electro-optic modulators with limited breadboarding.

PHASE II: Implement most promising modulator designs and incorporate into an optical RF link for evaluation.

COMMERCIAL POTENTIAL: Major applications to the commercial market are in satellite receiver systems for distributed RF signals over large distances with high signal quality; remoting of cellular radio systems by high-quality, low-loss RF photonics without the need for complicated and expensive digital processing equipment; and LANs for low distortion distribution of RF signals in large building complexes, aircraft, and television network systems.

DARPA SB971-015 TITLE: Wideband Photonic Radio Frequency (RF) Signal Processors

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Electronic Warfare

OBJECTIVE: Develop new concepts and approaches for wideband RF signal processing utilizing photonic devices and architectures.

DESCRIPTION: The intent of this topic is to solicit research and development leading to signal processors capable of wideband (multigigahertz) operation directly, without RF signal up/down conversion. Processors will be compact by virtue of their operation at the optical frequency and wideband, requiring no RF conversion, local oscillator distribution or intermediate frequency (IF) operation. Candidate areas of investigation are wideband signal detection and processing, antenna beamforming, jammer null steering, and multipath mitigation. Frequencies of interest are from 100 MHz-100 GHz. System applications are antenna systems, receivers, satellite communications, radar surveillance, electronic warfare (EW), and electronic signals intelligence (ELINT) systems.

PHASE I: Tradeoff concepts and designs to develop wideband RF processors with limited breadboarding.

PHASE II: Implement the most promising designs and incorporate into a system application.

COMMERCIAL POTENTIAL: Applications to the commercial market are in satellite receiver systems, cellular radio systems, and television receiver distribution systems.

DARPA SB971-016 TITLE: Stand Off Chemical and Biological (Chem/Bio) Hazard Detection

CATEGORY: 6.2 Exploratory Development; Chemical and Biological Defense

OBJECTIVE: Concept development and prototype design specifications for airborne chem/bio agent detection system.

DESCRIPTION: The technology to manufacture and employ chem/bio weapons is widely available to potential adversaries of future conflicts. The use, even threat of use, of these agents severely impacts military planning and fighting effectiveness. The development of a robust sensor system that would provide rapid information about the presence and nature of a biological threat to the battlefield commanders, within a short time line, will be required for future battlefield awareness. The ability to rapidly survey areas of potential or actual chem/bio weapon use will reduce the planning uncertainty, facilitate medical response to treat friendly forces, and perhaps deter or dissuade development of these weapons of mass destruction (WMD).

A sensor suite, which can be mounted on an aircraft or an unmanned aerial vehicle (UAV), could provide this wide-area, rapid-reaction chem/bio hazard surveillance. The ability to detect a wide array of potential threat substances at low concentrations and at long stand off ranges will require development of devices with significant increases in performance over technologies currently available.

PHASE I: Provide sensor system performance predictions for the recommended technologies. Perform concept definition study to address sensor integration with airborne platforms. Address size, weight, power, and processing requirements.

PHASE II: Provide detailed airborne sensor system designs. Develop and test breadboard component hardware which can lead to fieldable system hardware.

COMMERCIAL POTENTIAL: Successful conclusion of this development effort could lead to important sensing capabilities for civil defense, disaster response, seismic monitoring, and air quality monitoring.

DARPA SB971-017 TITLE: Aerostat Survivability

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications

OBJECTIVE: Explore and develop advanced techniques to improve the survivability of small and large aerostat systems.

DESCRIPTION: Tethered aerostats are receiving increasing attention for military use as a sensor host platform. One factor limiting their acceptance within the Services is survivability. Survivability threats to the aerostat (as a system) can be directed at either the airborne vehicle or the ground mooring station, and can include threats such as surface-to-air missiles (SAMs), cruise missiles, theater ballistic missiles (TBMs), strike aircraft, and special operations forces. This topic seeks to investigate innovative concepts and technologies to increase aerostat survivability. Examples might include mooring station hardening techniques for larger aerostat systems, or reduction of the observability of smaller, forward deployed aerostat platforms. Effectiveness analysis comparing baseline systems to proposed concepts would be expected of any winning proposal.

PHASE I: Propose and evaluate innovative concepts for survivability. Determine improvement factors over current approaches. Assess feasibility of implementation. Some limited component level demonstrations may be appropriate.

PHASE II: Build and test a prototype system to demonstrate the value of the proposed approach.

COMMERCIAL POTENTIAL: U.S. aerostat manufacturers serve an established market domestically and internationally for both military and commercial applications. For example, commercial systems have been sold to Korea, Iran, and Nigeria as communications nodes, and for TV and radio broadcast. Aerostats have also been proposed as long endurance environmental monitoring systems. Innovative ideas resulting from this SBIR such as lightweight systems, redundancy, ruggedization techniques, or innovative mobility concepts will improve the capability of aerostats to deploy to remote locations and thus expand the commercial market potential.

DARPA SB971-018 TITLE: Low-Cost, Miniature Unattended Sensor Systems

CATEGORY: 6.3 Advanced Development; Sensors

OBJECTIVE: Develop and demonstrate novel concepts for detecting, localizing, and classifying targets with arrays of low-cost, miniature, internetted, unattended ground and littoral sensor systems.

DESCRIPTION: The intent of this topic is to solicit research and development leading to the design and demonstration of novel, advanced, unattended sensor systems for the detection, localization, and classification of air, ground, and shallow water time-critical targets. Efforts may address individual miniature sensor systems, such as acoustic, seismic, chemical, environmental, orientation, geolocation, imaging, and magnetic systems; however, multisensor systems with local signal processing, data fusion, and an internetted communications capability are also of interest. Low-power, autonomous wake-up, and commanded wake-up capabilities for these unattended systems are required. Efforts of interest also include: low-power, extended-life, high-resolution sensors; efficient real-time, feature-based classifiers; environmental models for real-time transformation of sparse sensed data to predictions of area weather and propagation related parameters; decision aids to enable optimum configuration and processing of data from sensor arrays; and technologies to precision air deliver individual and arrays of unattended sensor systems from tactical aircraft, unmanned air vehicles, mortars, or artillery shells, including packaging of these sensor systems in submunition-sized configurations compatible with area denial missile systems, such as MLRS and ATACM systems. Parameters of interest that will be utilized to evaluate proposed sensor concepts are projected cost; size; weight; reconfigurability through modular design; power consumption; covert operations; and detection, localization, and classification performance. Aggregate metrics, such as dollars per kilometer squared detection coverage-hours of life, without battery change, will be utilized to compare proposed concepts. Parameters of interest that will be utilized to evaluate proposed aircraft and unmanned air vehicle delivery system concepts are projected cost, size, weight, stowage capability, altitude and delivery range capability, precision of delivery (CEP), and, for earth penetrating concepts, the capability to penetrate in varying soil conditions while still maintaining communications and in-situ sensing capability after delivery.

PHASE I: Develop concept description and initial design of sensor related system with clear description and quantification of key predicted performance parameters. A sensitivity analysis indicating the predicted performance of alternate proposed system configurations, including identification of highest risk aspects of the proposed design is required. Risk mitigation demonstrations and/or simulations of key high-risk aspects of the proposed design, to demonstrate proof-of-concept, is also required.

PHASE II: Develop final design and demonstration of the proposed sensor related system with post-demonstration analysis sufficient to demonstrate proof-of-performance for the proposed system. Complete design and demonstration documentation must be delivered.

COMMERCIAL POTENTIAL: The development of low-cost, high performance, modular, miniature sensor and related sensor delivery systems will expand the commercial markets for home and industrial security systems, industrial process monitoring systems, and environmental monitoring systems. Increased performance; component modularity for optimum domain specific tailoring of sensor configurations; and the dramatic reduction in size, weight, and cost of these sensor systems will increase the range of potential applications for these products.

DARPA SB971-019 TITLE: Mortar or Rifle Launched, Low-Cost, Miniature Ballistic and Glided Flight Surveillance Sensor Systems

CATEGORY: 6.3 Advanced Development; Sensors

OBJECTIVE: Develop and demonstrate low-cost, miniature, surveillance sensor systems that are ground deployed from either a mortar launcher or a rifle, and are retrievable.

DESCRIPTION: Small, highly mobile, dispersed forces need an organic capability to deploy and retrieve over-the-horizon capable (greater than 30 kilometers), miniature sensor systems to provide near real-time threat and terrain related information. Specifically, this topic seeks research and development leading to the design and demonstration of novel, rifle and mortar launched and retrievable surveillance sensor systems for the over-the-horizon detection, localization, and classification of ground and shallow water, time critical targets. Efforts may address individual miniature system components, such as advanced propulsion systems or sensor systems, as payloads for these ballistic and glided flight vehicles; however, concepts for complete mortar and rifle launched systems are preferable. The use of conformal and deployable wings and control surfaces is required to insure compact stowability and ballistic tube launching of these sensor systems. Parameters of interest that will be utilized to evaluate proposed concepts are projected cost, size, weight, flight duration, maximum altitude, effective trajectory path length from launch to return for recovery, stowage capability, reconfigurability through modular design, power consumption, covert operations, and sensor performance. Aggregate metrics, such as dollars per kilometer squared surveillance coverage, will be utilized to compare proposed concepts.

PHASE I: Develop concept description and initial design of the miniature, integrated sensor and vehicle system, with an imaging subsystem payload configuration with clear description and quantification of key predicted performance parameters. A sensitivity analysis indicating the predicted performance of alternate proposed system configurations, including identification of highest risk aspects of the proposed design, is also required. Risk mitigation demonstrations and/or simulations of key high-risk aspects of the proposed design, to demonstrate proof-of-concept, is also required.

PHASE II: Develop final design and demonstration of the proposed miniature, integrated sensor and vehicle system with post-demonstration analysis sufficient to demonstrate proof of performance for the proposed system. Complete design and demonstration documentation must be delivered.

COMMERCIAL POTENTIAL: Such technology would have tremendous commercial/dual-use applicability. The idea is to produce very small, lightweight sensors that could be projected out to ranges in excess of 10 kilometers in a simple and cost-effective manner, and then retrieved by having the sensor system return to the point of origin (like a boomerang).

This technology may be used for physical security systems for monitoring large complexes or areas such as airports, industrial plants, farms, forest areas, ranches, beaches, port operations, etc. Such systems would also be particularly useful for fire or disaster relief monitoring, where there is a need for small retrievable systems to provide a periodic air surveillance capability at relatively long ranges for large area or long perimeter searches.

By constraining the system to a miniature size, it could be projected into the air using a variety of means, such as ballistic launch from a medium sized tube (such as a mortar launching tube) or a very small tube (such as a rifle using a charge ranging from a bullet propellant charge to a larger, rifle propelled grenade sized charge of propellant). For purely commercial systems, an electric rail gun or a compressed gas system could be used to initially propel the sensor system into the air. Once in the air, these systems will have a recoverable and rechargeable propulsion system that will enable the sensor system to travel 10 plus kilometers and then return to the point of origin.

DARPA SB971-020 TITLE: Advanced Propulsion and Power Technologies for Micro Air Vehicle (µAV) Systems

CATEGORY: 6.2 Exploratory Development; Air Vehicles, Aerospace Propulsion and Power

OBJECTIVE: Identify and develop promising propulsion and power technologies for µAV systems and applications.

DESCRIPTION: The growth and maturation of µAV systems will be paced by improvements in propulsion and power technologies. Range, endurance and speed are parameters dominated by propulsion and power capabilities. The small size of the µAV requires consideration of high heat release and high-power density concepts. This topic is directed at innovative propulsion and power systems, and concepts that can provide significant new capabilities including fuels, powerplants, thermo-chemical systems, and battery and fuel cell concepts. Innovative, high-payoff ideas involving new technologies, as well as improvements to a variety of current schemes, will be explored.

PHASE I: Conduct preliminary design analyses and definition studies based on proposed propulsion/power schemes. Describe the potential, and outline how the concept(s) will be developed and matured. Identify the critical technology, design, and integration issues, and describe a plan to address them.

PHASE II: Develop the proposed concept/technology to a level sufficient to confirm the potential and assure adaptability to µAV applications. Conduct performance demonstrations. Growth and maturation requirements will also be identified and discussed.

COMMERCIAL POTENTIAL: Micro propulsion and power generation systems, especially those stressing energy conversion efficiency, have a wide variety of potential commercial and consumer applications. These include portable power sources/supplies in such applications as plant power and heating, system control devices, remote control devices, security systems, etc.

DARPA SB971-021 TITLE: Diver-Held Sonar

CATEGORY: 6.2 Exploratory Development; Sensors

OBJECTIVE: Develop a small hand-held combat diver sonar for shallow water search.

DESCRIPTION: Shallow waters are murky, harsh sonar environments with many false targets. It is well known that marine mammals can easily accomplish the identification of objects in murky waters. These sonars operate in the 50-150 kHz range, demonstrating that sonar is a feasible approach. This topic seeks to develop, build, and test a sonar small enough to be hand-held, with a microprocessor and display. The sonar parameters are a range of 30 meters in a water depth of 10 to 30 meters, a source level of 200 dB re (one micro-Pascal squared second), a size of the transducer of approximately 0.4 meters, and a processor in a helmet or strapped to the diver's arm. The total air weight should be approximately 10 lbs.

PHASE I: Develop the design and supporting sonar analysis of a diver-held sonar that meets the 30 meter range. Show that the design is feasible by the use of standard sonar analysis of the SW wave guide and computer simulation of the processor and display.

PHASE II: Based on the results of Phase I, construct a diver-held sonar prototype and demonstrate its utility in at-sea test.

COMMERCIAL POTENTIAL: The commercial potential for law enforcement search and rescue personnel is large. Currently, sonar technologies for lakes, rivers, and marshes are nonexistent. The search for objects and bodies requires a small mobile sonar.

DARPA SB971-022 TITLE: Antenna Element Location Measurement System for Millimeter Wave, Airborne Antennas

CATEGORY: 6.2 Exploratory Development; Electronics

OBJECTIVE: Develop distributed distance measuring technology to locate the relative location of antenna phase centers to enable large linear aperture, airborne antennas.

DESCRIPTION: The intent of this topic is to solicit research and development leading to the demonstration of a method to measure and compensate for the relative motion of aircraft mounted antenna elements in real-time. To maximize the aperture size of airborne antennas, it is desirable to locate antenna elements along the wings and/or the fuselage. However, flexing of the wings, fuselage, and other aircraft parts where the antenna elements are located can be rapid and large in amplitude, thus, introducing large phase uncertainties and spoiling antenna performance. It is impractical to make these aircraft structures rigid enough for millimeter wave antennas. The desired motion correction system will calculate, in real-time, the relative motion of each antenna element and calculate a phase offset to be applied to each antenna's signal to compensate for the antenna motion. The accuracy of the correction needs to be suitable for antenna operation up to 90 GHz.

PHASE I: Perform tradeoffs between different candidate approaches. Analyze and design the most promising measurement system. Conduct bench top tests and demonstrations to validate concept performance.

PHASE II: Field test a multi-antenna element, airborne antenna system with a sufficient number of antenna elements, to prove proper phase correction due to structure motion.

COMMERCIAL POTENTIAL: The development of large aperture, narrow beam width, millimeter wave antennas for vehicles (air and land) has many commercial applications, including collision avoidance, high bandwidth communications, and environmental remote sensing. Current systems have an aperture size limited to several feet, in part because of stability issues. With the proposed motion compensation system, an order of magnitude increase in aperture size would be practical.

DARPA SB971-023 TITLE: Robust Guidance, Navigation, and Control (GN&C)

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications

OBJECTIVE: Develop a broad range of advanced technologies to ensure highly reliable GN&C over a broad range of military mission scenarios and over the full spectrum of expected stressing battlefield environmental conditions.

DESCRIPTION: DARPA is pursuing technologies that will lead to improved Warfighter situational awareness, navigation, and self-location. These improvements can be manifested in a number of ways: increased capability for direct access of Global Positioning System (GPS) P(Y) coded waveforms, greater immunity to GPS receiver jamming, military applications of carrier phase tracking, lower energy (<<1 joule) positional fixes of GPS C/A and P(Y) codes, etc. Pursuant to these objectives, improvements are sought at both the technology and system levels. Example technologies are those that can perform massive, parallel correlations at low-energy; antenna systems that can form multiple simultaneous nulls (<-60 dB); signal processing that offers order of magnitude improvements in time, energy efficiency, or performance; advances in all aspects of time/frequency standards, etc.

PHASE I: Identify, study, analyze, and justify the various technologies to be pursued for robust GN&C. Where necessary, preliminary measurements and limited experimentation will be performed. At the completion of this phase, the program will be focused on definitized, quantified goals, and on those areas where the most payoff can be achieved.

PHASE II: Assemble and integrate the various technologies into areas for demonstration. Each area will include those technologies that focus on an overall goal. As an example, an overall goal for anti-jam protection may require antenna nulling, massive correlation, and precision timing. These demonstration areas will be pursued to achieve defined goals.

COMMERCIAL POTENTIAL: The development of low-energy GPS receiver systems; low-power and highly accurate time/frequency sources; and low-power, massively parallel correlators will add to the growing potential for the already ubiquitous GPS market.

DARPA SB971-024 TITLE: Unique Concepts for Rotorless High-Speed Vertical Takeoff and Landing (VTOL) Aircraft

CATEGORY: 6.2 Exploratory Development; Air Vehicles

OBJECTIVE: Conduct conceptual designs and critical technology validation of unique VTOL concepts with potential application for civil and military transportation of personnel and cargo.

DESCRIPTION: The intent of this topic is to solicit testing of technologies enabling later flight demonstration of VTOL concepts in the high subsonic speed regime. Unique concepts which go beyond the traditional helicopter rotor system approach are sought. Efforts may address any testing and simulation activities; for example, demonstration of propulsion system components, wind tunnel testing, or control system simulation, deemed critical to reducing technical risk.

PHASE I: In detail, define the aircraft application and develop conceptual design to support component testing and technology validation activities.

PHASE II: Conduct validation design and supporting model testing and simulation activities.

COMMERCIAL POTENTIAL: A VTOL aircraft without the range-reducing and passenger-disturbing effects of a rotor system will be attractive for short and medium length commercial passenger routes.

DARPA SB971-025 TITLE: Innovative Concepts For Space-Based Remote Sensing

CATEGORY: 6.2 Exploratory Development; Sensors

OBJECTIVE: Develop innovative techniques and concepts for high-resolution, electro-optical, or radar imaging of the earth's surface.

DESCRIPTION: Low-cost, innovative concepts for high-resolution space-based imaging of the earth's surface are needed. Short revisit times are required to track dynamic events, while at the same time coverage of relatively large areas is important to both commercial and military applications. These needs, taken together, currently imply very expensive solutions, which require either a few very large systems in high-altitude earth orbit (HEO) and/or a large number of systems in low-altitude earth orbit (LEO). Concepts employing technology available over the next 10 years, that significantly reduce costs, are needed.

PHASE I: Develop novel space-based concept(s) that can image the earth at high-resolution (less than 1 meter). Produce defensible performance and cost figures, taking into account all aspects of system production, launch, and operation. Indicate areas where technology development is needed.

PHASE II: Produce next level of design detail and cost models, and work with one or more aerospace companies to refine and red-team the results.

COMMERCIAL POTENTIAL: This technology has potential application to space remote earth sensing systems.

DARPA SB971-026 TITLE: Precise Attitude Measurement

CATEGORY: 6.2 Exploratory Development; Sensors

OBJECTIVE: Develop techniques for precisely measuring aircraft attitude.

DESCRIPTION: Measurement of absolute geo-coordinates of objects and features on the ground is an important capability. Electro-optical (EO) and radar remote sensing techniques exist for accomplishing these measurements, and both typically require precise attitude measurement ranging from 10 to 100 microradians at bandwidths of 1 Hz or greater. New, reliable, versatile, techniques are needed that push toward greater measurement accuracy and higher bandwidths. For example, solutions applicable to interferometric synthetic aperture radar (IFSAR) call for an ability to measure the attitude of a line passing through the phase centers of two or more antennas, which can be in motion due to flexure of the airframe. Solutions applicable to EO sensors might have to cope with flexure as well.

PHASE I: Develop affordable, robust, high-accuracy measurement techniques employing Global Positioning System (GPS), angle sensors, etc., capable of dynamically measuring aircraft attitude on the range from 10 to 100 microradians at 1 Hz or greater bandwidth.

PHASE II: Implement attitude-measurement technique on test aircraft to demonstrate accuracy.

COMMERCIAL POTENTIAL: This technology has potential application to airborne and possibly space-based, earth remote sensing systems.

DARPA SB971-027 TITLE: Advanced Synthetic Aperture Radar (SAR) Waveforms

CATEGORY: 6.2 Exploratory Development; Sensors

OBJECTIVE: Develop innovative SAR waveforms that address range ambiguity problems encountered with high-area-coverage-rate systems; e.g., low-earth-orbit (LEO) satellites with large-swath-width coverage.

DESCRIPTION: SAR systems capable of imaging large areas from space are of interest to both military and commercial users. Such systems operating in LEO must be designed so that range ambiguities resulting from large-swath-width coverage do not impact image quality. Solutions to this problem, such as backscanning, both limit area coverage rate, and impact the complexity and cost of SAR systems. Digital waveform generators allow the employment of innovative waveforms and signal-processing schemes to address this problem and potentially reduce system costs.

PHASE I: Design and simulate waveform(s) and processing algorithm(s) enabling useful improvements in SAR performance. Waveforms must be realizable with available or emerging digital waveform generation technology.

PHASE II: Implement waveform(s) and processing algorithm(s) in flight tests and demonstrations.

COMMERCIAL POTENTIAL: This technology has potential application to space remote earth sensing systems

DARPA SB971-028 TITLE: Scalable, Multifunction Communications Controller

CATEGORY: 6.2 Exploratory Development; Electronics

OBJECTIVE: Develop a scalable communications controller to function with software reconfigurable multiband, multimode radios that provide unattended, wireless network relay services for dynamic environments.

DESCRIPTION: Multiband, multimode radios are being developed that provide local area network users and/or application servers with the capability to access multiple, simultaneous wireless networks. This capability is being applied to terrestrial systems as well as to airborne vehicles. However, the inability to access the communications payload during long missions, when equipment fails, or when missions change offers unique challenges for reconfiguration or maintenance of systems in an airborne environment. An intelligent, scalable communications controller is needed to provide gateway, router, and bridging services to communication payloads of varying complexity. This capability is particularly needed by communications payloads, such as the Airborne Communications Node. A controller operating in this environment will be required to change gateway, routing, and bridging configurations during a long endurance mission. This controller will also be required to function with various payload configurations, connection response times, bus loading, multilevel security requirements, and data rates. The controller must be scalable to implement a broad range of functions using a variable selection of resources for each mission.

PHASE I: Define a system level approach for achieving the scalable communication controller and produce a preliminary design. Estimate the expected level of performance of the controller and develop a detailed Phase II plan.

PHASE II: Fabricate elements or modules of the controller and integrate into a device capable of demonstrating attainable performance.

COMMERCIAL POTENTIAL: Communications controllers are needed to enable terrestrial and satellite-based wireless Personal Communication System (PCS) and cellular services to provide the personalized mobile network management capabilities envisioned.

DARPA SB971-029 TITLE: Rapid Model Development

CATEGORY: 6.2 Exploratory Development; Modeling and Simulation

OBJECTIVE: Reduce the model construction, validation, and insertion time by a factor of 10, and reduce the cost by a factor of 5.

DESCRIPTION: Current technology for constructing and validating ground order of battle target models for use in high-frequency, high-resolution, synthetic aperture radar (SAR) template-based and model-based automatic target recognition (ATR) systems is a time consuming, labor intensive process. Innovative model construction and validation tools, techniques, and processes that facilitate the rapid insertion of new or modified target models into fielded ATR systems are desired for completely accessible targets and inaccessible targets for which models must be developed by remote sensing means. Improvements in each part of the process, including model construction, data collection, data reduction, and data analysis to support validation, or the process as a whole, taken from an integrated model building and validation system perspective, are solicited. Innovative ideas that significantly reduce the time and cost required to rapidly construct, validate, and insert models in response to new or modified target threats are of particular interest.

PHASE I: Develop and implement rapid target construction, validation, and insertion methods, tools, and concept of operation. Benchmark the time and cost of current model development and insertion processes.

PHASE II: Apply and validate the Phase I rapid model development methodology by producing a minimum of five high fidelity, validated ground target models. Demonstrate that the new process meets stated time and cost objectives.

COMMERCIAL POTENTIAL: An advanced, rapid model development process has significant potential for commercial object recognition systems. In particular, this technology can be straightforwardly applied to automated roadway vehicle detection and recognition systems.

DARPA SB971-030 TITLE: Hyperspectral and Synthetic Aperture Radar (SAR) Fusion for Concealed Target Detection

CATEGORY: 6.2 Exploratory Development; Sensors

OBJECTIVE: Create and implement techniques for target detection using SAR and hyperspectral imagers.

DESCRIPTION: The intent of this topic is to solicit development of techniques for exploitation of multispectral and multisensor data to detect targets, particularly those targets concealed by foliage and man-made obscuration. Emphasis should be placed on algorithms for exploitation of image data from several platforms, including ultrawideband foliage penetration (FOPEN) radar and hyperspectral visible through short wave infrared imagers. Techniques should consider spatial and spectral adaptive filtering, geolocation and image registration techniques, change detection, and multisensor data correlation in order to fully exploit the differences between sensors for detection and identification of man-made objects. Because the sensors may be operated on separate platforms, particular attention should be paid to object detection and false alarm probabilities, and the attendant effect on bandwidth of information transfer to remote image exploitation centers. Assessment of algorithm processing requirements and implementation on high performance computers is important in understanding practical implementation of techniques in real-time surveillance systems.

PHASE I: Develop or identify unique data fusion and correlation techniques. Assess the feasibility of the techniques developed on actual and simulated ultrawideband SAR data and hyperspectral visible through short wave infrared data.

PHASE II: Develop prototype software for demonstration tests. Test operation in conjunction with radar and hyperspectral data collections.

COMMERCIAL POTENTIAL: The quantity of radar and hyperspectral data available in the commercial sector is soon to increase rapidly with the commercial availability of hyperspectral instruments and the launching of a number of new radar satellites. This will increase the demand for better algorithms to extract useful information from a large quantity of imagery. Also, image understanding techniques have tended to concentrate on a single data source. Techniques developed under this topic will be applicable to the problem of extracting useful information from this mass of data and exploiting the complementary capabilities of the different imaging systems.

DARPA SB971-031 TITLE: Foliage Penetration (FOPEN) Interferometric Synthetic Aperture Radar (IFSAR) Techniques

CATEGORY: 6.2 Exploratory Development; Sensors

OBJECTIVE: Develop processing techniques to improve performance of FOPEN IFSAR systems in mapping applications.

DESCRIPTION: The intent of this topic is to solicit development of techniques to exploit IFSAR data for terrain height estimation, land use and target classification, and other mapping and geographic information system applications. It has been shown that synthetic aperture radar (SAR) images from two apertures can be used to estimate height and provide accurate digital elevation maps (DEM). By lowering the frequency of the IFSAR images to the

UHF band while retaining necessary bandwidth, significant FOPEN can be obtained, providing the potential for DEM at true ground level. New ultrawideband processing techniques are needed to exploit this FOPEN IFSAR technology for rapid estimation of the terrain elevation, and for utilization of fully polarimetric returns from IFSAR images for classification of the biomass, terrain features, and man-made objects. These processing techniques should consider the need for simultaneous versus repeat pass IFSAR on the accuracy and fidelity of DEMs and classification. It is anticipated that representative data will be made available to verify processing techniques developed under this project.

PHASE I: Describe innovative processing techniques. Where possible, explore the feasibility of techniques with existing SAR imagery. Extrapolate performance-to-performance with single-pass FOPEN IFSAR. Describe relative benefits of innovative technique over current practice.

PHASE II: Implement a prototype of the new processing technique. Demonstrate performance with recorded SAR imagery from commercial or military data collection platforms.

COMMERCIAL POTENTIAL: These processing techniques will be applicable to UHF radars currently under development and may have wider application to a number of higher frequency systems in current commercial operation. Turn-around time is critical for some commercial operations and is primarily limited by processing time. Therefore, techniques developed under this topic that utilized distributed or parallel workstations could find wide application in both the civilian and military sectors.

DARPA SB971-032 TITLE: Electromagnetic Interference (EMI) Mitigation in Multiband, Multifunction Communications Nodes

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications

OBJECTIVE: Develop technology/tools to analyze/mitigate EMI in co-sited multifunction communications nodes.

DESCRIPTION: Highly capable multiband, multifunction radios and modern computer technology will soon be available, giving the military capability of establishing remote, autonomous, possibly airborne, communications nodes. Airborne communications nodes, in particular, will require remote/autonomous operation. It will be possible to simultaneously link multiple, diverse units through the communications node only if the multiple systems do not interfere with each other at the node. EMI from co-siting is expected to be a major problem.

The goal of this topic is to define and develop one or more technologies to mitigate EMI in communications nodes. This topic encompasses the necessary analysis, trade studies, design, and development activities to address the issues resulting from simultaneous operation of multiple transceivers and/or simultaneous multichannel operation. These modes of operation introduce simultaneous, multiple modulations and frequency-hopping sets across HF, VHF, UHF, and SHF bands, and the associated issues of intermodulation, receiver desensitization and co-site interference. Mutual interference is anticipated from proximity of transmit frequencies to receive bands, receiver characteristics, harmonics/spurs and noise produced by transmitters and circuits available at the communications node. A comprehensive approach is required at the outset, particularly for airborne nodes, to determine and solve EMI problems.

Candidate EMI mitigation techniques include, but are not limited to, the following: 1) a comprehensive frequency management plan, 2) over the air control of operating frequency for operation in changing environments, 3) antenna design and placement to minimize co-site interference, 4) design and use of multifunctional antennas, 5) design and location of filters and multicouplers/receiver isolation, 6) interference cancellation techniques/adaptive nulling technologies, 7) dynamic antenna allocation for operational flexibility, 8) power budgeting to establish effective minimum radiation, and 9) receiver blanking during transmission.

PHASE I: Define tasks to develop EMI mitigation plan. Recommend approach and preliminary design. Estimate expected level of mitigation. Develop detailed Phase II plan.

PHASE II: Carry out/analyze the full mitigation effort.

COMMERCIAL POTENTIAL: Personal wireless communications and networking will require efficient bandwidth management and co-sited systems. Technologies to enhance capabilities of these systems will be increasingly important. In addition to application in military airborne communication nodes, EMI and co-site interference mitigation techniques have direct application in commercial communication systems, including improvement of existing cellular communication systems and the airport tower replacement program for vehicular installation of a mix of seven VHF and UHF radios to support disaster contingency plans.

DARPA SB971-033 TITLE: Dynamic Database (DDB) Technology for Battlefield Awareness

CATEGORY: 6.2 Exploratory Development; Computing and Software

OBJECTIVE: Create the information management technology to enable a dynamic, shared, distributed repository for information about all aspects of the battlespace, including terrain, buildings, vehicles, and forces, in a common geospatial and temporal reference frame.

DESCRIPTION: The intent of this topic is to solicit research and development leading to the creation of a dynamic battlefield database capable of supporting hypothesis, model, and terrain updates; responding to ad hoc queries; and publishing tailored products for selected users. The approach is to establish DDB as a continually updated, electronic model of relevant portions of a battlespace. The DDB will allocate available memory to maintain coverage, granularity, and ambiguity at a level consistent with changing user needs. Work is needed on: memory-efficient data representations and time-efficient search techniques for massive amounts of battlefield information; extended query languages to handle spatial, temporal, and uncertainty characteristics in user's queries; archive management to allocate and de-allocate memory as information ages and users' foci of attention change; integrity controls to eliminate erroneous updates and allow recovery in case of hardware failure; pedigree management to maintain source histories for individual facts and hypotheses in the database; and techniques to update and predict terrain attributes from whatever data may be available, including maps, digital Defense Mapping Agency (DMA) products, electro-optical stereo pairs, synthetic aperture radar (SAR) imagery, interferometric synthetic aperture radar (IFSAR) elevation maps, and commercial imagery.

PHASE I: Define, in detail, the application, algorithm, and approach to providing one or more of above software capabilities.

PHASE II: Create the software system which delivers the functional capabilities defined in Phase I. Complete documentation of test cases and results must be delivered.

COMMERCIAL POTENTIAL: The development of efficient information management techniques for dynamically updating and managing massive databases of geospatial information has enormous commercial potential. With the advent of commercial satellite imagery services and the growth of geographical information systems for a wide variety of commercial services, there is a growing market for more sophisticated information management products tailored to the management of massive amounts of dynamically changing geospatial information.

DARPA SB971-034 TITLE: Architectural Components for Semantic Interoperability

CATEGORY: 6.3 Advanced Development; Computing and Software

OBJECTIVE: Develop a semantic-based approach to sharing and understanding information within a very large, multiservice, multiple echelons of command, heterogenous system of systems.

DESCRIPTION: Current DoD Command, Control, Communications, Computers, and Intelligence (C4I) systems deal with extremely large volumes of data with complex requirements in very heterogeneous hardware, software, and communications environments. Future DoD systems are likely to be much larger and more complex than today's, supporting a wide range of diverse user requirements over all four Services, multiple echelons of command, and multiple mission areas, such as Planning, Mission Rehearsal, and Operations. Both Coalition, Joint, and individual Service needs must be addressed.

Current approaches to achieving interoperability among these diverse systems have serious limitations. Specifying standards (RS-232, IEEE 802.3, Posix) or message syntax (Internet Protocol, Distributed Interactive Simulation protocol, Aggregate Level Simulation Protocol) are the most common approaches, since computers are extremely good at interpreting standards and syntax. However, the semantics for a computer system are usually implicit in the mind(s) of the designer(s). Extremely heterogeneous systems imply few assumptions that are valid over the entire system, leaving little room for implicit semantics because there is no shared context among the sub-system developers. The Semantics Challenge is the following: how can one create explicit semantics which are structured enough for computer-based analysis, yet expressive enough for DoD problems?

PHASE I: Create a detailed design which shows how semantic interoperability might be achieved in a large scale, extremely heterogeneous environment.

PHASE II: Create an initial implementation, illustrating semantic interoperability among a diverse set of components which does not rely on shared context among the developers, but instead deals with semantic issues explicitly, providing for computer-based analysis and composition.

COMMERCIAL POTENTIAL: Current business models already use a wide variety of contractors to develop multiple components which must ultimately interact in a coherent fashion to produce an integrated system. This approach is difficult to scale because of the large number of interfaces which must be managed and semantic issues which must be resolved through face-to-face interactions of the human designers. If the software components could self-describe their operations in a way amenable to computer interpretation, much larger systems could be composed automatically, opening entirely new business areas and fostering the growth of virtual consortiums to rapidly create new products.

DARPA SB971-035 TITLE: Nonlinear Warfare Initiative

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Modeling and Simulation

OBJECTIVE: Develop capability to model and predict nonlinear effects of actions taken to achieve military and national goals.

DESCRIPTION: The information-based Revolution in Military Affairs, as well as modern, information-driven business practices, operates on the premise that acting on the right information at the right time will enable highly leveraged, “nonlinear” effects to be achieved in a market or against a competitor’s or adversary’s key weaknesses (centers-of-gravity). There are currently no useful measures of effectiveness (MoEs) for nonlinear effects in business practice or military operation. Neither are there useful methods or tools for analyzing systems and situations to identify significant adversary’s weaknesses that could be exploited using relatively little energy (e.g., adding a specifically defined feature, getting to market first, or destroying a critical communication node). Little exists for analyzing vulnerabilities that could be similarly exploited. A variety of methods can be used to achieve nonlinear effects. In business, these might include product positioning strategies, risk management techniques, and image management. For the military, these include precision munitions, small maneuverable forces, and information warfare (IW).

This topic will focus on scenarios to: 1) develop methods for modeling and reasoning about nonlinear effects, 2) identify and exploit competitive opportunities, 3) develop extensions to planning tools to include IW-based battle management (including active IW, Defensive Information Warfare (DIW), and perception management) and precision munitions effects, 4) develop MoEs and analysis methods for nonlinear warfare and identification of centers-of-gravity, and 5) apply MoEs to Course of Action (COA) analysis for nonlinear effects (positive and negative). Results from this program will be used at several levels to guide future technology development and acquisition decisions, create plans that coordinate the employment of actions that will bring about nonlinear effects, and evaluate friendly situations and plans for possibly catastrophic weaknesses.

PHASE I: Investigate basic methods for modeling and reasoning about nonlinear effects using a scenario-based approach and develop MoEs for nonlinear effects.

PHASE II: Select the most promising methods for development resulting from Phase I investigation and explore extensions to planning tools to include IW-based battle management, precision munitions effects, and perception/image management. Phase II will also apply MoEs developed in Phase I to analysis of COAs for nonlinear effects.

COMMERCIAL POTENTIAL: This technology will allow analysis of business opportunities and COAs. It could also be used to estimate potential catastrophic effects of natural forces (hurricanes, earthquakes), environmental accidents (oil spills, toxic emissions), and financial changes (bank failures).

DARPA SB971-036 TITLE: Technology for Mixed-Initiative Information Exchange and Coordination in Collective Activities

CATEGORY: 6.2 Exploratory Development; Command, Control and Communication; Computing and Software; Human Systems Interface

OBJECTIVE: Develop protocols and sample implementations supporting sharing, exchange, and coordination of information in settings combining human and automated processes in distributed workgroups.

DESCRIPTION: The intent of this topic is to solicit research and development on protocols that support coordination and control of activities in distributed work systems in settings that combine automated processing with computer-mediated human processing.

The goal is to create a shared work environment distributed over the Internet, or intranets based on the Internet, that supports the widest possible range of modes of working for distributed organizations. This means the environment must support both synchronous and asynchronous cooperation between people and other people, between people and automated processes, and between process-to-process. It should support an open hyperdocument structure with shared data and objects. In addition to informal cooperation, the environment should also support structured process and workflow. The environment must be relatively open because the participants who must be coordinated cannot necessarily be identified in advance.

Key technical developments lie in the protocols that support such systems and enable them to be comprised of interoperating components (including both new components, and legacy components which have been wrapped with software compliant with the protocols). Three areas of development are of interest:

(1) Mechanisms supporting sharing, exchange, and integration of information at the document level and/or object level by building upon, extending, or integrating protocols such as COM/DCOM, OLE/ActiveX, CORBA, OpenDoc/CyberDog, HTML, HTTP, Protocol Extension Protocol (PEP), JAVA RMI, and JavaBeans;

(2) Mechanisms supporting distributed process control and workflow, by building upon, extending, or integrating protocols such as Process Interchange Format (PIF), Mail API Workflow Framework (MAPI-WF), and products of the Workflow Management Consortium such as Process Definition Metamodel and Workflow Process Definition Language (WPDL), Client Application APIs, Process Definition Interchange, and Workflow Administration and Monitoring Standards; and

(3) Mechanisms supporting “agent-based” computing (characterized by processes which may persist across interactive sessions, may accept tasks to perform described at a relatively high level, may perform semi-autonomous planning to determine how to perform their tasks, and/or may negotiate with other processes to determine whether and how sub-tasks will be performed by those other processes). Work in this area involves building upon, extending, or integrating protocols such as OMG Mobile Agents facility, JAVA, TeleScript, and Knowledge Query and Manipulation Language (KQML).

Advances and extensions in any of the three areas listed above are of interest. However, because the goal requires systems that combine the virtues of multiple approaches, developments that bridge across two or more of these areas are of even greater interest. Although not areas of specific interest, efforts should show sensitivity to emerging protocols for information discovery (e.g., the Harvest summary object interchange format or Dublin metadata specification) and security (e.g., S-HTTP, SSL, OSF/DCE).

PHASE I: Identify feasible extensions/integrations of existing protocols and document benefits.

PHASE II: Develop, test, and document proof-of-concept implementations.

COMMERCIAL POTENTIAL: The technology developments sought will speed the development and acceptance of Intranets that serve to link members of distributed organizations, thus speeding and enhancing their information exchange. Specifically, these developments will enhance the capabilities offered by such Intranets, while simultaneously providing a bridge that integrates enhanced process and workflow capabilities into them. Thus, work in this area will bring together two markets (Intranet tools and process/workflow technology), each of which is independently expected to expand by two orders of magnitude in the next decade. Tools that bridge those markets also have direct applications in DoD initiatives in intelligence, crisis management, and logistics.

DARPA SB971-037 TITLE: Visual Tracking of Human Figures

CATEGORY: 6.2 Exploratory Development; Human Systems Interface

OBJECTIVE: Design, build, and demonstrate a system to track human motions as a means for interacting with virtual worlds, for controlling computer systems, or for detecting human activities from overhead reconnaissance video.

DESCRIPTION: Detection and tracking of human figures in dynamic scenes is an emergent technology fostered by past image understanding (IU) research and the advent of multimedia in the commodity markets. Current systems can track moving figures in a scene to varying degrees of reliability. The impact of this technology will increase significantly as methods for recognizing temporal events in tracking data become available. Examples would include techniques for recognizing and classifying suspicious behavior events for security applications, or gestural events for advanced video communications and visual interfaces. Exploitation of reconnaissance video will be enhanced by the ability to identify, track, and recognize the movements of people automatically.

PHASE I: Perform implemented feasibility studies of the key components of a system for tracking the movements or gestures of one or more humans. Identify key technology gaps. Formulate system development plan.

PHASE II: Build, demonstrate, and evaluate the system. Demonstrations should permit live interaction with selected subjects from the audience. Evaluation should compare reliability, accuracy, and flexibility with that attainable from nonvisual devices.

COMMERCIAL POTENTIAL: Interaction with virtual reality systems and other entertainment products is hampered by dependence upon cumbersome electronic devices involving wires attached to the subject or the required installation of equipment in the room. Visual tracking of motions and gestures would permit more flexible monitoring of human activities. These devices have a ready market in the entertainment industry, as well as the military simulation and visualization industry. Additional applications of the underlying technology include automatic search in video databases and very low bit-rate compression.

DARPA SB971-038 TITLE: Design of Global Positioning Satellite (GPS) Receiver Module on a Single Silicon Chip

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Electronics

OBJECTIVE: Complete circuit design, including simulation of circuit performance, to the point just prior to initiation of fabrication.

DESCRIPTION: The operating speed of silicon digital circuitry is approaching the radio frequency (RF) range. In the near future, it may be possible to exploit this performance to transfer to silicon certain electronic functions currently done in III-V compounds. This offers a higher level of integration of circuit functions such as a single chip that provides all the functions in a GPS receiver. This will lead to a reduction in cost, and generate new applications as an embedded component in a wide range of electronic systems.

PHASE I: Explore the circuit design approach and define transistor parameters, device design, and wafer processing sequence to meet the RF requirements. Explore the availability of fabrication lines having compatible wafer processing.

PHASE II: Do a detailed circuit design, simulate circuit performance, and provide layout design of the circuit. Breadboard test circuit elements to verify required operational capabilities in critical design areas.

COMMERCIAL POTENTIAL: The civilian market for such circuits has been established for some time; their costs are in the range of $200-$500. The GPS module has numerous applications in areas such as guidance in airplanes and ships, surveying, and even location aids in rental cars. The availability of smaller, cheaper units will dramatically increase the number of applications. The all-silicon version will greatly expand its usefulness as an embedded component. It can then be readily combined with controller, memory, and computational functions for an endless variety of commercial, industrial, and civilian uses.

DARPA SB971-039 TITLE: Solid-State Imaging Sensors

CATEGORY: 6.2 Exploratory Development; Sensors, Electronics

OBJECTIVE: Demonstrate new concepts for solid-state sensors with spectral response in the near- to far-infrared (one to ten microns).

DESCRIPTION: Sensors with spectral response in the near- to far-infrared are necessary to extend the range of current imaging systems. Sensors with response in this spectral range have the potential to detect targets at long ranges in cluttered environments. For the long wavelength infrared sensors, the next level of performance requires dramatic improvements in the infrared material quality, design of novel structures used to support the detector, and low noise signal processing to address the detector and read-out multi-element arrays. Thin films of infrared sensitive material are necessary to provide the low thermal mass necessary to meet imaging system requirements in the long wavelength infrared. The thin film material must be deposited on structures which thermally isolate the detector and, at the same time, provide electrical contact to the low noise input amplifier. Material deposition requirements must be compatible with the signal processing fabrication technology. In the near-infrared (one micron to two micron), the higher spectral radiance, relative to the visible, can provide improved night vision capability. Unique target characteristics in this spectral region can also provide imaging capability, and possibly target discrimination, not possible in other spectral regions. However, high-density, two-dimensional, solid-state, one to two micron arrays, with the performance required for military night vision, are not available. The primary limitation is unavailability of background limited sensitivity in large format two dimensional arrays. This program addresses sensors in both the near- and far-infrared; these may be demonstrated as an individual sensor or as part of an integrated imaging system.

PHASE I: For the far-infrared sensors, define the approach to material deposition and thermal isolation structure design. The potential for material meeting the program goals will be established through deposition on existing thermal isolation structures. For the near-infrared sensors, demonstrate test structures with sensitivity in the one to two micron spectral region. The devices will be characterized for signal to noise, responsivity, and spectral characteristics.

PHASE II: Design and fabricate a two-dimensional imaging array. The array will be integrated into a broad band optical system for imaging in the near- to far-infrared.

COMMERCIAL POTENTIAL: Uncooled infrared sensors have numerous potential commercial applications. These include non-destructive evaluation, preventive maintenance, police use, fire fighting, and border patrol. Improvements made in this program establish the technology for these applications, especially in the development of small pixels with high sensitivity.

DARPA SB971-040 TITLE: Volumetric Three-Dimensional (3-D) Display Technologies

CATEGORY: 6.2 Exploratory Development; Electronics; Materials Processes and Systems; Human Systems Interface; Command, Control and Communications

OBJECTIVE: Demonstrate 3-D display technologies which allow multiple viewers to perceive objects with a real-time, realistic, volumetric perspective.

DESCRIPTION: Various approaches to 3-D technology today have met with limited success. This includes the use of stereoscopic displays based on differential polarization, liquid crystal shutters, and multiple image planes projected in a time sequential fashion. What is truly desired by the DoD user is a 3-D rendering that can be observed by multiple users in an unencumbered fashion that displays real-time data. Applications include air traffic control, medical uses, and submarine navigation, as well as command post “sand tables” to depict entire battlefields. Early prototypes of such systems have been produced either through holographic projections or laser illumination of spinning elements, but each of these need higher resolutions to be more widely applicable.

PHASE I: Define and test concepts needed to demonstrate volumetric 3-D imaging, including image sources, viewing characteristics, and system size. It is not necessary during Phase I to demonstrate viewing of real-time data; however, the capability of such a system to demonstrate this should be rigorously addressed. Preliminary experimental characterization of concepts during Phase I is desirable.

PHASE II: Fabricate and characterize a 3-D volumetric display prototype to demonstrate the operational characteristics of the proposed systems. Demonstration in one of the application formats described above is required. The prototype device may be monochrome, although color is preferable. Estimation of total system costs in production are also required.

COMMERCIAL POTENTIAL: The development of a 3-D volumetric imaging system would have many direct analogs in the commercial world, particularly in navigation and medical systems. Given sufficient reduction in system cost, broader acceptance in commercial products, such as computing and television applications, are also possible.

DARPA SB971-041 TITLE: Multifunctional Optoelectronics Integration for Information Processing Systems

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Computing and Software; Electronics

OBJECTIVE: Develop and demonstrate technology to "integrate" silicon-based electronic and optoelectronic components at the chip level to achieve multifunctional integration. In particular, two new technologies, lift-off and thermal-, or fusion-, bonding, which integrate at the "chip"/"wafer" level, have emerged which promise to not only significantly reduce the cost, but also the size, weight, and volume of the integrated function while effectively providing functional integration with little or no deterioration in performance.

DESCRIPTION: The focus of this topic is to develop and demonstrate prototype fabrication processes of multifunctional integrated circuits targeted to application areas which have high-payoff to the military and commercial applications. The areas of primary interest are optoelectronic interconnect transceivers and switches for military and commercial applications below 10 meters, and uncooled integrated sensors and detectors/emitters for ultraviolet (UV) missile threat warning.

There is a rapidly increasing need to integrate disparate materials to achieve higher degrees of functional integration - Multifunctional Integration. This is particularly true for information processing with the need to bring together optoelectronics, and analog and digital technologies to enable the new multimedia systems of the future. Several efforts to achieve monolithic integration have been pursued in the past with only limited success. While multichip module (MCM) packaging addresses similar needs, new technologies which integrate at the "chip"/"wafer" level have emerged recently and are demonstrating significant promise to provide cost-effective, functional integration, with little or no deterioration in performance. Two examples of these new technologies include lift-off and thermal-bonding.

PHASE I: Perform research and development into assessing the limits of lift-off and thermal/fusion-bonding in terms of area/array size that could integrate silicon circuits with vertical cavity surface emitting laser (VCSEL) and detector technology, and develop cost models with integration complexity. Demonstrate preliminary experimental concept regarding the capability of using these two "integration" technologies to integrate VCSEL emitters and detector with silicon electronics.

PHASE II: Extend techniques developed in Phase I to develop and demonstrate a viable transceiver/smart pixel array technology incorporating VCSEL emitter and driver, detector and receiver amplifier integrated on silicon integrated circuit. The extent of the array size to be demonstrated will depend on the required logic in the pixel or smart transceiver array and the specific application. It is important to demonstrate the potential of the approach to scale up to full-scale production and demonstration of the transceiver link.

COMMERCIAL POTENTIAL: Demonstration of the full potential of this technology and development of the processing and fabrication technology promises to provide significant payoff in a very broad spectrum of applications having major commercial significance. Applications include computer data communication, local area networks, fiber-to-the home (the last mile), commercial and military avionic networks and backplanes, smart displays and head/helmet mounted displays, and smart pixel-based focal plane array sensors. The exploitation of lift-off and fusion-bonding technology has been limited, as the processes to "integrate" lasers and to perform integration over large arrays on silicon has only recently been developed.

DARPA SB971-042 TITLE: Simulation, Modeling and Computer Aided Design (CAD) Tools for Optoelectronics Components

CATEGORY: 6.2 Exploratory Development; Command, Control and Communications; Computing and Software; Electronics

OBJECTIVE: Design and develop new optoelectronic devices and integrated circuits through optimization of computer simulation and modeling of semiconductor materials and device structures for applications in high-speed signal processing and computation.

DESCRIPTION: Combining optical and electron devices into optoelectronic systems has emerged as the methodology of choice for enhancing the speed performance of signal processing, computation, and telecommunications. Significant advantages in speed, power, weight, and size appear if monolithic integration of the electron and optic devices on a single semiconductor substrate is achieved. Different materials' properties for the separate electronic and optical devices make it difficult to design and optimize the performance of the devices and circuits. Computer simulation methods have emerged as a critical element in the process of designing electronic devices and circuits. Numerical simulations need to be developed for optical devices such as lasers, modulators, waveguides, and detectors for design and optimization of optoelectronic, integrated circuits. Such simulation and modeling will greatly reduce the development costs and assist designers in optimizing circuit designs.

PHASE I: Numerical simulation methodologies will be chosen and developed for computer modelling of integrated semiconductor optoelectronic devices and circuits, in which device physics and circuit performance are addressed and optimized with respect to threshold current, output power, efficiency, and modulation frequency.

PHASE II: The procedures developed in Phase I will be extended to consideration of devices in which small dimensions leading to quantum effects are dominant. These results will be validated by coordination with experimental programs at commercial, university, and government laboratories. Designs will be proposed which lead to the highest speed circuits of interest to telecommunications, computation, and signal processing.

Computer programs developed will be optimized and packaged for use on varied computer platforms available to broad classes of research interests at the research level, in engineering design, and in commercial fabrication. Such computer platforms include supercomputers and engineering workstations.

COMMERCIAL POTENTIAL: Development of CAD optoelectronic tools will significantly enhance the capability of U.S. industry to exploit the full potential of optoelectronics technology. Development of these tools promises to provide significant payoff in a very broad spectrum of applications having major commercial significance. Applications include computer data communication, local area networks, fiber-to-the home (the last mile), commercial and military avionic networks and backplanes, smart displays and head/helmet mounted displays, and smart pixel based focal plane array sensors. The exploitation of lift-off and fusion bonding technology has been limited as the processes to "integrate" lasers and perform integration over large arrays on silicon has only recently been developed.

DARPA SB971-043 TITLE: Advanced Vertical Cavity Surface Emitting Laser (VCSEL) Technology

CATEGORY: 6.2 Exploratory Development; Electronics

OBJECTIVE: Develop VCSEL device designs that address methods of improving laser performance for specific applications.

DESCRIPTION: This topic seeks to accelerate the further development and military availability of VCSELs which have emerged as an approach to laser diode design that have many advantages for information systems applications. While substantial progress has been made for short wavelength devices utilizing Gallium Arsenide materials, there are substantial remaining issues that require further development to meet the requirements for specific systems applications. These include designs that enable operation at wavelengths compatible with fiber optic communications systems (those operating in the 1300-1500 nm range); designs that provide wavelength control, both static and dynamic (wavelength tuning); and methods for incorporating oxide materials for reducing threshold current and providing improved laser mode control.

PHASE I: Demonstrate a proof-of-concept design, either through fabrication of prototype diodes or by detailed modeling, for a practical means to achieve any of the cited improved performance objectives.

PHASE II: Develop and demonstrate a fully functional prototype capable of demonstrating critical functionality, and provide design documentation for a full-scale implementation.

COMMERCIAL POTENTIAL: There is expanding interest in VCSELs for information processing systems ranging from optical data links to printers and displays. The development of robust designs addressing the issues cited above would open the potential market for these devices to fiber optical communications, wavelength division multiplexed systems, and other applications where the performance of current devices is limited.

DARPA SB971-044 TITLE: High-Speed Fiber Optic Network Access Modules (NAMs)

CATEGORY: 6.3 Advanced Development; Electronics

OBJECTIVE: Accelerate the development and availability of high-speed fiber optic NAMs.

DESCRIPTION: This topic seeks to leverage recent advances in packaging of high-speed electronics, and high-speed, low-cost-to-manufacture laser transmitters or optical modulators to enable a compact, robust, hybrid package providing an interface between high performance electronic systems and fiber optic communications links. Candidate technologies include high-speed, heterojunction, bipolar transistor electronics and advanced integrated laser arrays, and/or efficient, high-speed, optical modulators. Of particular interest is the possibility of polymer-based modulators capable of meeting the full range of military specifications for robust operations.

PHASE I: Demonstrate a proof-of-concept NAM design including laser package, receiver and drive electronics, and optoelectronic modulator, either through fabrication of prototype components or by detailed modeling of designs based on demonstrated performance of existing components.

PHASE II: Develop and demonstrate a fully functional prototype NAM capable of demonstrating critical functionality, and provide design documentation for a full-scale implementation.

COMMERCIAL POTENTIAL: There is a growing market for information system links based on robust NAMs that permit easy interconnection between high-speed, high performance electronic systems and fiber optical networks.

DARPA SB971-045 TITLE: Innovative Research in the Area of Digital Receivers for Radar, Electronic Warfare, and Communications Applications

CATEGORY: 6.2 Exploratory Development; Electronic Warfare, Sensors

OBJECTIVE: Develop novel ideas to extend the performance and integration of several, miniaturized subsections for a digital receiver to be contained on a large multichip module (MCM) or small printed wiring board (PWB).

DESCRIPTION: The intent of this topic is to solicit research and development of innovative ideas for a digital receiver (spurious free dynamic range of at least 80 dB) to be fully contained on a large MCM or PWB, and to contain several miniaturized, interconnected subsections. Efforts should address novel ideas that would extend the performance and integration in module functional areas such as: 1) a tunable radio frequency (RF) front end (either digital or analog, with center frequencies between 20 Mhz and 18 Ghz, and bandwidths of at least 1 MHz) containing a noise shaping/anti-aliasing filter and low noise amplifier (LNA), 2) a high-speed A/D converter and demultiplexer module, 3) a backend digital signal processor (using COTS devices if available), and 4) a power conditioner and direct digital synthesizer for the tunable or frequency agile implementations. Efforts of interest might include networking techniques, digital filters and their variations, LNAs and front end filtering, direct digital synthesizers, Fast Fourier

Transform (FFT), digital RF memories, power supplies or power conditioning, and techniques for noise suppression.

PHASE I: Provide a detailed digital receiver subsection or component design and simulation demonstrating feasibility of the approach as it pertains to integration into a digital receiver.

PHASE II: Construct a prototype version of the Phase I subsection or component design and fully test for comparison with simulations.

COMMERCIAL POTENTIAL: Development of digital receivers will further enhance the capability, performance, and cost effectiveness of several applications including computer networks, Global Positioning System (GPS), and cellular and satellite communications. Programmability, and size and weight reductions, enabled by the integrated MCM format, will have important implications for portable electronic products. Individual subsections may ultimately become standard products for integration and enhancement of larger systems.

DARPA SB971-046 TITLE: Semiconductor Nanostructure Modeling

CATEGORY: 6.1 Basic Research; Command, Control and Communications; Electronics; Materials, Processes and Structures; Manufacturing Science and Technology; Modeling and Simulation

OBJECTIVE: Develop commercial software for the design and modeling of quantum effects influencing the transport and optical properties of semiconductor nanostructures, which will have impact on advanced microelectronics.

DESCRIPTION: Layered quantum semiconductor structures, such as quantum wells, superlattices, and double barrier resonant tunneling structures, are evolving beyond the prototype stage and need to be incorporated into electronic VLSI structures and photonic (optoelectronic) structures. The behavior of mobile carriers in semiconductor heterostructures, with layering and patterning at the nanoscale, is influenced by the quantum confinement effects. The energy bandgap and localization of the carrier wavefunction, which is controlled through the geometry of the heterostructure, profoundly influences optical and transport properties in such "subdimensional" structures. Computational modeling, including quantum effects through the use of a multiband description, effects of modulation doping, and external fields, provides feed-back into: 1) in-situ monitoring of crystal growth in molecular beam epitaxy (MBE) machines and the analysis of device characterization experiments, 2) the design of new structures, 3) active device modeling, 4) clarification of basic quantum concepts and their implementation in semiconductor devices, and 5) a means for implementing the incorporation of such structures into commercial VLSI CAD-CAM. The software should be capable of including material properties of the group IV, III-V, and I-VI semiconductors placed in layer, quantum wire, and quantum dot (subdimensional) geometries. The finite element and tight-binding algorithms must be computationally efficient, minimizing CPU time and using dynamic memory allocation. The software should be capable of giving energy levels and wavefunctions of carriers, overlap integrals and optical matrix elements, tunneling currents, effects of quantum confinement of carriers on dielectric properties and optical waveguiding. The effort will primarily be evaluated on its impact on nanoelectronics.

PHASE I: Develop the basic algorithms and the core of the calculation to show proof-of-concept by formulating tight-binding models and a finite-element algorithm for treating layered structures with arbitrary semiconducting materials in the layers. Authenticate implementation of boundary conditions by comparing results with other quantum computational methods and experimental results.

PHASE II: Develop a fully general, finite-element algorithm for treating structures with arbitrary geometry along all three spatial dimensions with arbitrary semiconducting materials. Include computation of transport and optical properties of such structures.

COMMERCIAL POTENTIAL: Continued microminiaturization makes inevitable the need to include quantum effects in chip design. The new class of optoelectronic devices based on quantum effects require novel methods for their modeling. While the immediate market for such a package is within the electronics and optoelectronics research and development groups in industry, government, and universities, there is a potentially much larger market in the chip manufacturing industry. A powerful computational package will provide a major impetus to device design and subsequent subsystem development.

DARPA SB971-047 TITLE: Nanoelectronic Structures and Devices

CATEGORY: 6.1 Basic Research; Command, Control and Communications; Electronics; Materials, Processes and Structures; Manufacturing Science and Technology; Modeling and Simulation

OBJECTIVE: Develop electronic devices with critical feature sizes well below 100 nanometers to accelerate the development and military availability of high-speed, low-power electronics for advanced digital radar; digital elint receivers; and secure, high data rate, digital networks.

DESCRIPTION: Recent advances in materials processing and fabrication techniques have made it possible to produce device structures with characteristic dimensions down to a few atomic layers. New classes of devices are emerging or being conceived. Many of these manifest quantum mechanical effects, such as tunneling, quantum phase interference, or coherence. Proposals are invited addressing processing, fabrication, characterization, and modeling of quantum devices. It is important that fundamental issues be addressed while concentrating on devices with realistic potential for DoD applications. Room temperature operation is sought. Particularly relevant are devices with possible low-power and high-frequency or high-speed applications. In modeling efforts, proposals are encouraged that incorporate self-consistency and dissipation as well as realistic boundary conditions. Material efforts are encouraged to explore heterojunction systems for silicon-based nanoelectronics, and chemical self-assembly for its potential in nanoelectronics.

PHASE I: Clearly demonstrate the feasibility of the proposed approach and its relevance toward processing, fabricating, and implementing sub 100 nm devices and circuits for enabling microelectronics beyond current trends in integrated circuit semiconductor technology. Clear indication needs to be given as to how the particular approach and concept will improve performance characteristics in speed, power, and/or density.

PHASE II: Build upon Phase I work and ultimately demonstrate the properties, characteristics, and performance of device structures and circuits in the nanometer regime (well below 100 nm) and how it will lead to substantially improved performance in Phase III plans for system insertion and application is such areas as digital radar, elint receivers, signal processing, and electronics for communications networks.

COMMERCIAL POTENTIAL: This technology could lead to new concepts in advanced electronic devices and new device architectures, and be the basis for high-frequency signal generation, high-speed switching, and multivalued data storage.

DARPA SB971-048 TITLE: In-Situ Tools for Molecular Beam Epitaxy (MBE) Process Control

CATEGORY: 6.1 Basic Research; Command, Control and Communications; Electronics; Materials, Processes and Structures; Manufacturing Science and Technology; Modeling and Simulation

OBJECTIVE: Develop in-situ monitoring techniques and process control for reliable, reproducible growth of nanoelectronic devices.

DESCRIPTION: Advances in material processing and fabrication techniques have made it possible to produce device structures, well into the quantum regime, with characteristic dimensions down to several atomic layers. MBE is the pre-eminent technique for growth of these state-of-the-art electronic device structures. The use of MBE for growth of elemental and compound semiconductor structures has resulted in improved microelectronic device performance, and has spawned entirely new classes of novel materials and structures which continue to extend the limits of technology. These advances result from the capabilities of MBE to achieve very abrupt junctions in complex layered structures; to fabricate ultra-thin semiconductor layers with well-defined thickness and composition; and to grow compositionally uniform alloys of binary, ternary, and quaternary semiconductor materials. Continued demands for improved device performance and simultaneous reduction in production costs have made MBE-process reproducibility and reliability, and device yield, vital technological imperatives. These considerations dictate that the use of in-situ sensing and feedback control of the MBE process is essential.

The focus should be on producing low-cost systems, including sensors, control algorithms, and hardware. Redesign of the MBE hardware for better control capability is also allowed under this topic. Especially encouraged are new in-situ monitoring techniques and approaches which will allow epitaxial layer control down to atomic dimensions. Non-destructive techniques are of interest which obtain data on layer thickness and uniformity, alloy composition and uniformity, dopant concentration and uniformity, substrate and epitaxial layer temperature, strain, source/flux characteristics, and other pertinent characteristics.

PHASE I: Select an approach and demonstrate its feasibility in allowing epitaxial layer control for advanced electronic devices with dimensions well below 100 nanometers. Cost, non-destructive nature, ease of implementation, sensitivity, and simplicity of the approach will be considered.

PHASE II: Construct, assemble, fabricate, manufacture, or retrofit the sensor/s, diagnostics, or hardware. Demonstrate the approach to grow reliably and reproducibly thin epitaxial layers. Demonstrate applicability of technique on advanced electronic device structure. Efforts addressing control must demonstrate replacement of conventional "dead-reckoning" approaches to MBE with a true real-time, feedback controlled system. Software commercialization needs to be addressed. Ideally, Phase II would address in-situ sensing and feedback control of the MBE process in producing specific quantum devices (especially silicon-based).

COMMERCIAL POTENTIAL: This technology will assist in the automation and more cost-effective growth of advanced material structures, reliable electronic and optoelectronic device structures, improved high-frequency electronics, and quantum well detectors and emitters.

DARPA SB971-049 TITLE: Nanoprobes for Advanced Device Processing

CATEGORY: 6.1 Basic Research; Command, Control and Communications; Electronics; Materials, Processes and Structures; Manufacturing Science and Technology; Modeling and Simulation

OBJECTIVE: Develop nanoprobes for nanoelectronic device diagnostics and/or high throughput scanning tunneling microscopy (STM) for ultra small structure and device processing.

DESCRIPTION: STM has recently been shown to be an excellent tool for lithography to 0.1 micrometer dimensions. This region is currently inaccessible to optical and e-beam lithographic techniques. STM, on the other hand, is capable of atomic level resolution and is surprisingly easy to operate in the nanometer resolution regime. This reduced scale opens up a new area of device physics and technology. Entirely new families of quantum devices can potentially be processed onto existing chips with this technique. Concurrently, as we go to smaller device structures, there is a need for diagnostic tools, both spatially and temporally.

PHASE I: Define the operational criteria that will allow STM to become an effective high throughput tool to current device processing equipment and/or define and develop diagnostic "nano-tools" which will enhance the ability to characterize advanced device structures well below 0.1 micrometer.

PHASE II: Construct/fabricate the nanoprobe diagnostic tools and/or high throughput STM that will be retrofitted into existing processing equipment. The device will be qualified by the production of quantum device structures on the surface of silicon.

COMMERCIAL POTENTIAL: This technology could possibly accelerate the utilization of quantum devices in advanced electronic circuits. The nanoprobe tools would allow for new commercial diagnostic equipment and would increase the fundamental understanding of extremely small structures - electronic, optical, and mechanical. This technology may leverage the development of maskless lithography which would be of benefit to the commercial integrated circuits industry, which has annual world sales in the billions of dollars.